Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods

(Busan, Republic of Korea, 9 to 13 March 2015)

Contents

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Introduction

1.1 The 2015 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Haeundae Grand Hotel, Busan, Republic of Korea, 9 to 13 March 2015. The Convener, Dr X. Zhao (People's Republic of China) welcomed the participants (Appendix A). He also thanked Dr S.-G. Choi (Republic of Korea) and colleagues from Korea's National Fisheries Research and Development Institute (NFRDI) and Ministry of Ocean and Fisheries for hosting the meeting. Dr Zhao also thanked Dr R. Kloser for his participation in the meeting as an invited expert.

1.2 Dr Choi extended a very warm welcome to all participants. He stated that it was a great pleasure to host this meeting of SG-ASAM in the harbour city of Busan, the second largest city in Korea. Haeundae Beach, on the doorstep of the meeting, is a most beautiful and famous landmark. He wished all participants a happy stay in Busan and a productive and successful meeting.

1.3 The Subgroup has been considering the use of fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*) (SC-CAMLR-XXX, paragraphs 2.9 and 2.10; SC-CAMLR-XXXI, Annex 4). This meeting continued developing the protocols for collection and analysis of acoustic data collected on board fishing vessels and this work was guided by the following terms of reference (SC-CAMLR-XXXIII, paragraph 2.20):

1. Proof of Concept and Stage 2 (data collected during a range of vessel activities, speeds and weather conditions to assess more fully the quality and utility of acoustic data from commercial fishing vessels)

2. Protocols for data collection and analysis, with emphasis on Simrad echosounders (EK60, ES60/70)

    2.1 Data collection

    - Validation of instrument performance (internal and external reference target, with focus on the role of seabed as reference target for individual and inter-ship calibration, taking into account of inputs from fishing vessel masters)

    - Instructions on instrument setup

    - Work on protocols for data collection with other echosounder/sonars where applicable

2.2 Protocol for data screening and analysis

- Noise removal algorithms (standardized procedures)
- Data analysis (software-specific)
- Uncertainty evaluation methods

3. Analysis of data collected during fishing operations

- Spatial and Statistical treatment
- Potential input into WG-EMM on the use of fishing vessel based acoustic data in the 2015/16 multi-national effort as well as in feedback management (FBM) in general.

1.4 The meeting's provisional agenda was discussed, and the Subgroup agreed to extend the agenda to include an item on 'Other issues and future work'. The meeting agenda is in Appendix B.

1.5 Documents submitted to the meeting are listed in Appendix C. In addition, discussions during the meeting were also guided by presentations which are listed in Appendix C. The Subgroup thanked the authors of papers and presentations for their valuable contributions to the work of the meeting.

1.6 This report was prepared by A. Cossio (USA), O.R. Godø (Norway), D. Ramm and K. Reid (Secretariat), C. Reiss (USA), G. Skaret (Norway) and J. Watkins (UK). Sections of the report dealing with advice to the Scientific Committee are highlighted (see also 'Recommendations to the Scientific Committee').

Review of proof of concept and stage 2

2.1 Dr Watkins presented an overview of a draft paper entitled 'The use of fishing vessels to provide acoustic data on the distribution and abundance of Antarctic krill and other pelagic species' which had been written by scientists involved in SG-ASAM and submitted recently to a special issue of *Fisheries Research* on 'Fishing vessels as scientific platforms'. This paper summarised the proof of concept study undertaken to date. The Subgroup agreed that this represented a very useful summary and an excellent way of informing a wider audience about the work of CCAMLR.

2.2 In particular, the Subgroup noted that stage 1 data had been submitted from vessels belonging to a large portion of the fleet engaged in krill fishing in the Convention Area.

2.3 The Subgroup agreed that the range of acoustic data submitted from krill fishing vessels to date had met the objectives of the proof of concept study, fully demonstrating the ability to collect acoustic data from fishing vessels to provide data on the abundance and distribution of krill over time and space scales that were not available using conventional research surveys.

2.4 Stage 2 data have not been formally requested as yet although some data had been submitted and various analyses of acoustic data collected from fishing vessels had been submitted by Norway, the Republic of Korea and China. The Subgroup therefore focused its discussion on the actions needed to be undertaken to move to the next stage of the development of protocols and recommendations for data collection, data processing and data analysis as illustrated in the road map shown in Figure 1 of the SG-ASAM-14 report (SC-CAMLR-XXXIII, Annex 4).

2.5 The Subgroup noted that once the system is set up, then logging digital data is simple and low cost. It therefore agreed that the preferred option for stage 2 data and beyond was to log the echosounder continuously during the period the fishing vessel is within the subarea(s) it is licenced to fish for krill.

2.6 The Subgroup agreed that collecting acoustic data in this way from all krill fishing vessels capable of recording digital data would allow the most comprehensive assessment of variation in data quality under different conditions and activities.

2.7 The Subgroup agreed that to facilitate this data collection, the following actions were needed:

(i) define a complete range of metadata required to describe and interpret the acoustic data

(ii) create a complete document of instructions that provides sufficient detail to enable vessels to collect the acoustic data and the appropriate metadata

(iii) provide a listing of nominated transects for collecting acoustic data.

2.8 The Subgroup considered the hierarchy of metadata in the ICES (2013) document on metadata standards and an example of operational acoustic metadata that can be found at http://imos.org.au/badoc.html. The Subgroup noted that the metadata hierarchy comprises the following broad categories of metadata:

(i) metadata compiled for each vessel that can be collected at the time of notification and licensing

(ii) metadata required for instruments (detailing the echosounder for collecting the data being submitted)

(iii) metadata required to describe a particular voyage that can be collected from vessel monitoring system (VMS) and catch data

(iv) metadata generated during the analysis process(es), the details of this will be developed as the analyse protocols are developed.

2.9 The Subgroup agreed that accurate metadata was essential to the use of acoustic data and noted that the hierarchy of metadata was important to identify and minimise the essential elements that needed to be collected at the time the data were collected as there were many elements that could be extracted from information already supplied to CCAMLR, such as in the vessel licensing, notification, catch data and the raw acoustic data. An efficient process for metadata collection and entry should be designed to ensure that information is not duplicated and, once entered, metadata should only need to be entered again if values are changed.

2.10 While the examples referenced in paragraph 2.8 illustrate the potential complexity of a fully operational metadata system, the Subgroup noted that the reality for the metadata collection required from the fishing vessel during fishing was limited to recording the start and end times of nominated transects.

2.11 The Subgroup agreed that ancillary data, such as sea state or wind force, were essentially a proxy measure for vessel motion. Information about ship motion might help explain changes in the quality of acoustic data, but the same weather conditions might have very different effects on the quality of acoustic data from different ships. It was noted that ship motion logging is used in the Integrated Marine Observation System (IMOS) bioacoustics to correct the data as it has important implications for acoustic estimation at mesopelagic depths (200–1 000 m).

2.12 The Subgroup agreed that the main determination of whether particular acoustic data were suitable to be used for a particular purpose would be based on the quality of the acoustic data itself, rather than a particular value in the ancillary data. Therefore, the collection of specific ancillary data was not obligatory at this stage.

2.13 The Subgroup agreed that determining when a vessel was fishing was possible using the catch and effort (C1) data that is already submitted to CCAMLR. Other activities, such as searching or relocating, were difficult to determine, however, they could be determined in the analysis stage on the basis of speed and course.

2.14 The Subgroup noted that there would also be metadata that would be required for particular methods of processing and analysis of the submitted acoustic data and that these metadata requirements would need to be specified as those detailed processing steps were agreed at future meetings.

2.15 The Subgroup prepared an instruction manual for the collection of fishing-vessel-based acoustic data, based on discussion at this and previous meetings (2012 and 2014). This manual facilitates the collection of data to provide qualitative and quantifiable information on the distribution and relative abundance of krill (Appendix D).

2.16 The Subgroup agreed that collecting acoustic data on CCAMLR transects (SC-CAMLR-XXXIII, Annex 4, Table 2) was a priority activity. Recognising that there is a large number of such transects, the Subgroup selected a subset of these from each subarea on the basis of their biological and oceanographic interest. The Subgroup agreed that, in order to use the data collected along these nominated transects to investigate temporal variation in krill abundance, the transects should be sampled as frequently as possible during fishing (Table 1).

2.17 To facilitate the detection of these nominated transect data within the acoustic data collected continuously during the period the fishing vessel is within the subarea(s) it is licenced to fish, it was agreed that nominated transect metadata (subarea, transect numbers, start and end times) should be recorded during the voyage.

Protocols for data collection and analysis

Protocols for data collection and analysis, with emphasis
on Simrad echosounders (EK60, ES60/70)

3.1 The Subgroup recalled from the SG-ASAM-14 meeting that work to establish data collection protocols for Simrad echosounders had started, but that some elements of the protocols needed evaluation and others required further exploration and development subsequent to intersessional work on the issues.

Data collection

3.2 The Subgroup welcomed Dr Kloser who described the acoustic data components of the Australian IMOS as an example of how scientific data from vessels of opportunity can be collected, stored and distributed. The Subgroup agreed on the importance of benefitting from the knowledge base generated by IMOS to more efficiently develop the collection of acoustic data from the krill fishing fleet in CCAMLR.

3.3 The IMOS program uses vessels of opportunity to acquire high-quality basin-scale data with focus on the mid-trophic level.

3.4 The development of the program included a proof-of-concept phase which showed that the data collected had the potential to provide valuable information about different aspects of ecosystem state at several temporal and spatial scales. A required part of the implementation of the program was also the development and documentation of protocols for calibration, data collection, processing, metadata and indicators.

3.5 At present, 23 vessels are providing acoustic data for the program, collecting data on various numbers of echosounder frequencies. The selection of vessels is based on their ability to carry out annual sphere calibrations, conducting repeated transects, ease of interaction with the vessels and the cost of processing the data.

3.6 Dr Kloser highlighted the amount of work invested in the data processing at various levels. Automated correction for absorption and sound velocity with depth as well as motion corrections are added to the data for each frequency. Evaluation and removal of noise is also an essential part of the processing and algorithms are run for removing spike noise, intermittent noise, background noise and handling attenuation. The algorithms need to be tuned to suit the data and the output needs to be monitored. In addition, there are macro data issues, including loss of GPS signal, incorrect clocks (i.e. vessel time), limitations to the spike filters and limitations due to attenuation. Presently, eight of the 23 vessels collect 70% of the data which are used, and some vessels are not able to produce reliable acoustic data for use in the program.

3.7 Systems for data storage and making data available have been developed in IMOS and the data are now open for free use by the scientific community.

3.8 Dr Watkins presented an update on the status of the Southern Ocean Network of Acoustics (SONA) project, which aims at implementing a self-sustaining, long-term acoustic observing strategy of the mid-trophic level (krill, zooplankton and other pelagic organisms) in the Southern Ocean. This international project has several of the same goals as IMOS, including developing common standards and methodologies for acoustic data collection and processing, and creating an open-access database of acoustic observations of the mid-trophic level. Several international partners involved in SG-ASAM are also involved in SONA, and the minimum requirement to enter the SONA partnership is to share the data with the other partners.

3.9 SONA has developed techniques for extraction of metadata from EK60 raw data, and the project holds a database with calibrated S_v data stored in 5 m vertical × 500 m horizontal resolution which allows for different techniques to be used for target identification. SONA has also adopted several of the IMOS techniques for noise removal, but some of them require tuning to work consistently on the data which have been tested so far.

3.10 The Subgroup noted that since several initiatives for large-scale data collection existed, common conventions for metadata formats should be encouraged. The Subgroup also agreed on the importance of the metadata, the processing history and the processing algorithms being available to the users for all the data.

3.11 The Subgroup agreed that CCAMLR's existing rules for data access and use applied to data collected on krill fishing vessels and that the application of these rules to acoustic data should be formally clarified with data owners and providers.

3.12 Three potential storage locations of the data were discussed: the CCAMLR Secretariat, national institutions and data collection programs like SONA and IMOS. The Subgroup agreed that, although the Secretariat might be one of the storage locations of raw acoustic data, it may be more appropriate to give the Secretariat access to these data from other storage locations. It further agreed that instead of developing its own framework for storage, searching and distribution of data, CCAMLR should draw on the development taking place in IMOS and SONA.

Validation of instrument performance

3.13 The Subgroup recalled from last year's meeting that it was recommended to study alternative calibration methods to standard sphere calibration. Even though such methods might be less accurate than sphere calibration, they should be simpler to carry out and, thereby, allow more fishing vessels to be calibrated and provide CCAMLR with more acoustic data suitable for a greater range of analyses.

3.14 In particular, the Subgroup requested studies using seabed as reference target and encouraged Members to collect such data for further development of the method.

3.15 Dr Skaret presented a study on using the seabed for acoustic calibration with reference to data collected on the Norwegian-flagged krill fishing vessel *Juvel* in the South Orkney Islands krill surveying area, as well as on board the RV *G.O. Sars* in a Norwegian fjord. The data from the Southern Ocean were collected using a sphere-calibrated ES60 echosounder system running 38, 70 and 120 kHz transducers. Two different reference stretches at about 100 m and 300 m depth were used, and data from 2012 and 2015 were compared. The results showed high consistency within experiments, but were not consistent when compared between years.

3.16 The Subgroup noted that the integrated backscatter was generally lower in 2015 than in 2012, even though the echosounders had undergone a standard sphere calibration prior to both experiments. At present, it is not known whether the difference is caused by instrument performance or changes in bottom reflection. Also, it was noted that there was a larger difference between 38 kHz and 70 kHz at location 2 (300 m) compared to location 1 (100 m), which is probably caused by depth.

3.17 Dr Skaret noted that there have been some problems with the sensitivity of the 38 kHz transducer, which were discovered during the sphere calibration in 2012. This has impacted the results from the seabed calibration. He further noted that this work is at present inconclusive and in progress and will be continued during upcoming surveys.

3.18 Dr Kloser suggested using area backscattering instead of volume backscattering of the bottom echo as the data then would be independent of depth. He further indicated that, instead of using median, comparing mean values might be more appropriate and the Subgroup agreed that reanalysing the data taking this into account would be useful.

3.19 The Subgroup discussed various properties of the candidate seabed calibration location to be considered:

- depth should not be so great that the background noise is a problem in the analysis. The depth at which background noise interferes with seabed calibration will be frequency specific

- the bottom signal is impacted by the movement of the vessel and this could be monitored by recording the motion of the vessel or analysing the phase angle of the bottom signal

- it would be useful to know the bottom type along the reference stretch as this might explain variation in backscattering

- each calibration site should be characterised according to its acoustic backscattering properties.

3.20 The Subgroup also discussed using a fixed location versus transects for seabed calibration and agreed that both approaches might be valuable and welcomed contributions from Members to elucidate the issue.

3.21 The Subgroup emphasised that the sphere calibration still represents the benchmark method for validation of echosounder data. However, the Subgroup noted that the seabed calibration method had the potential to be very valuable as:

(i) a quick system check of acoustic system performance for vessels which have already had their echosounders sphere calibrated earlier in the season or in previous seasons

(ii) an alternative calibration method for uncalibrated vessels through inter-vessel comparisons

accepting that the results from (ii) will have uncertainties associated with them and would not be appropriate for stock assessment but could be used for distributional and other studies.

3.22 Recognising that the desirability of having acoustic data from vessels that have undertaken a standard sphere calibration, the Subgroup discussed the potential for designating a list of preferred calibration sites in each subarea that could be used by fishing vessels to undertake such a calibration.

3.23 The Subgroup requested the Secretariat to investigate the potential to provide sets of calibration equipment that could be kept at research bases near each calibration site at Cumberland Bay, South Georgia; Scotia Bay, South Orkney Islands; and Admiralty Bay, South Shetland Islands.

3.24 Dr M. Kang (Republic of Korea) described two challenges associated with standard sphere calibrations of Simrad ES60 echosounders:

- ES60 echosounders add a triangular wave noise function in the transceiver to degrade the signal. While such a noise function has no overall effect on echo-integration at the survey level, it can cause a problem during calibration. Dr Kloser noted that software available from CSIRO can be used to remove this systematic noise.

- Although angle information from the sphere is visible on the screen, there is no calibration procedure in the ES60 software. Data therefore have to be logged and post-processed in software such as Echoview before the calibration coefficients can be estimated.

Instructions on instrument setup

3.25 The Subgroup recognised that the requirement of instrument setup on board fishing vessels might differ for both nominated transects and periods of fishing operations and reviewed the recommendations for instrument settings given in Table 5 and Appendix D of the SG-ASAM-14 report (SC-CAMLR-XXXIII, Annex 4). The Subgroup agreed that the maximum data collection range should be increased from 1 000 to 1 100 m to enable more efficient noise removal without decreasing the ping rate interval set at 2 seconds (see Appendix D, Table 2, for nominated transects).

3.26 The Subgroup encouraged all Members to use the instruction manual (Appendix D), including, where possible, translation into the language used on the vessel, and to implement the data-collection procedures in the manual in their krill fishing fleet in the present season. The experience from such an exercise would provide useful guidance for possible future modifications.

Data screening and analyses

Noise removal algorithms (standardised procedures)

3.27 The Subgroup recalled last year's discussion recommending the study of noise removal methods in relation to data collected from the fishery which were considered more likely to be contaminated by noise than data from scientific vessels.

3.28 Dr Zhao presented the work carried out in SG-ASAM-15/02. The work was presented in a generalised framework (see presentation, Appendix C) which served as an example for documenting and reporting noise removal.

3.29 Dr Kang presented the application of a noise removal technique on a very noisy example of acoustic data of a dense aggregation.

3.30 The Subgroup welcomed both presentations and acknowledged that there was a principle difference between removing noise in contaminated data, and filling in data gaps using adjacent mean values, which was presented as part of the noise-removal algorithms. While the mean value is likely to be similar, the variability is reduced when data-filling methods are used. The Subgroup therefore advised Members to report how much of the data has been removed or filled in.

3.31 The Subgroup recognised that filling in discarded pings could be useful and may be necessary for estimating swarm geometry and behaviour. However, the Subgroup agreed that the statistical implications of this process need to be factored into analyses using such data.

3.32 The Subgroup agreed that information on background noise is very useful to record, and is important information for noise-removal algorithms to work properly and for reviewing data quality in general. Procedures developed by Simrad to evaluate background noise based on data collected with the echosounder in passive mode are available and the Subgroup encouraged the submission of such information for evaluation.

3.33 The Subgroup encouraged further work on noise removal, but agreed that the ideal solution is to identify the source of the noise and eliminate it. The Subgroup noted that interference from other acoustic instruments could be a major source of noise and that synchronising such instruments could eliminate this noise.

3.34 The Subgroup welcomed the range of approaches presented and recognised the desirability for a standard set of protocols for noise removal. Members were encouraged to compare and evaluate the performance of their algorithms.

3.45 Dr Kloser noted that the experience from the IMOS project had revealed that uncertainty in data output from vessels of opportunity is typically difficult to quantify appropriately, and that both negative bias can be introduced due to a low signal-to-noise ratio and positive bias due to, for instance, contaminating signals from interfering instruments. A 'traffic light approach' where data from each vessel is categorised according to simple quality criteria could be a useful approach in such a case to address the uncertainty.

3.36 The Subgroup welcomed the presentation from Dr Godø of a software program developed at the Institute of Marine Research (IMR) in LabView for synchronising signal triggering between two Simrad sonars, Simrad EK60 echosounders and a Furuno sonar. The software is available upon request from IMR.

Data analysis (software-specific)

3.37 Dr Skaret presented SG-ASAM-15/01, where the R-package EchoviewR (Harrison et al., 2015) allows for efficient automated acoustic data processing in Echoview via the

Echoview COM protocol. The package presently contains 46 functions and is freely available for download. The automated procedure considerably reduces the manual and supervised part of the processing time and decreases the risk of subjective errors in the processing. As an example, the package allows for automation of several key processing steps for obtaining a biomass estimate from an acoustic krill biomass estimation survey, including the krill identification through the dB-difference method. The package presently does not allow for automatic noise removal.

3.38 The Subgroup welcomed the method of automated processing and agreed that it was useful, in particular, that open-source processing tools would increase the ability for different groups to make use of the tools, including the Secretariat.

3.39 The Subgroup recognised that a full model implementation of the stochastic distorted-wave Born approximation (SDWBA) for target strength (TS) estimation, as recommended in the CCAMLR protocol for krill biomass estimation, is at present only implemented and available on the Matlab platform, and encouraged Members to work on a version of the package to be available in open-source software.

Analysis of data collected during fishing operations

4.1 Dr H. Lee (Republic of Korea) presented examples of acoustic data from two Korean fishing vessels: the *Sejong* running Simrad ES70 38 and 200 kHz and the *Kwang Jae Ho* running ES70 38 and 120 kHz, which had been fishing in the South Orkney Islands and Bransfield area in 2013/14. The data were collected using the settings of SC-CAMLR-XXXIII, Annex 4, Table 5. The presentation included an example of noise removal on 200 kHz data following the noise-removal scheme described in SG-ASAM-15/02.

4.2 The Subgroup thanked Dr Lee for the presentation and in particular noted that the quality of the example data was very good given the sampling range and the frequency. Dr Lee noted that the whole dataset will be processed and analysed as part of future work.

4.3 The Subgroup noted that high-quality data had been collected by a national observer and encouraged all Members to include appropriate training in their observer training programs to ensure that observers can include acoustic data collection in their tasks when on the vessel.

4.4 Dr Reiss noted that the vessels had been transiting the Bransfield Strait on several occasions along lines of similar length and direction as the transect lines comprised in designed surveys. The information from the acoustic recording along such lines could be used to evaluate krill density, and if repeated several times through a season, the temporal development of krill density, which is highly relevant information for the krill management. The Subgroup agreed that this demonstrates the high relevance and applicability of data collected by the fishing fleet.

4.5 SG-ASAM-15/03 summarised an analysis that simulated the use of data that might be available from the commercial fishery (using single-frequency acoustic data and varying length-frequency distributions of krill) on estimates of krill biomass in the South Shetland Islands. The analysis showed that significant variability in relative biomass estimates can be obtained when length-frequency data are truncated and used in different survey areas and with different acoustic frequencies. The authors showed that models developed using a wide length-frequency distribution (Elephant Island) could be used to estimate biomass from other areas where the length frequency of animals is skewed towards larger animals, but differed considerably when length frequencies were skewed towards smaller animals that the commercial fishery might not sample efficiently. They emphasised that it is possible to develop semi-empirical models of krill biomass at 120 kHz frequency that can be used to augment research acoustic surveys if proper survey design and calibration of transducers is maintained and if time series are sufficiently long to average out differences among years.

4.6 The Subgroup thanked the authors of SG-ASAM-15/03 and noted that acoustic properties of the 38 kHz or 70 kHz transducers may provide more stable estimates for these single-frequency applications. The Subgroup also noted that it may be necessary to revisit the automated dB differencing approach in order to ensure high-quality data.

4.7 Dr Godø presented preliminary analyses from acoustic data collected during the 2011 fishing season by the Norwegian fishing vessels around the South Orkney Islands. He provided a variety of results highlighting the wide utility of commercial acoustic data for understanding spatio–temporal variability in krill on the fishing grounds and its potential use in developing ideas for FBM. The Subgroup concluded that the breadth of analyses demonstrated the richness and utility of krill acoustic data collected by the fishery. The Subgroup encouraged further exploration of the data and its combination with data from a range of sources to better understand how to reflect local fishing conditions and/or broader spatial patterns of krill behaviour and incorporation into statistical models and operational procedures and analyses for FBM.

4.8 Dr Godø also presented an alternative use of acoustic data from the fisheries, where the dB-difference technique had been used to filter krill out of the echogram and visual inspection of the remaining echo traces was used to quantify diving activity of penguins. He noted that, while the method and analysis was still at an exploratory stage, it held promise and could potentially provide a link between krill monitoring and land-based predator monitoring.

4.9 The Subgroup welcomed the work examining predator foraging using acoustic data and noted that the analysis was carried out on raw data. While aggregated data are still appropriate to use for biomass estimation, the present work would not have been possible to be carried out using aggregated data. This illustrated the requirement for data to be archived at a level of resolution which suited their intended use.

Spatial and statistical treatment

4.10 There were no papers submitted under this agenda item. The Subgroup discussed the recent increase in publications that could provide insights into novel analysis techniques for incorporating commercially acquired acoustic data into the assessment and management process. Dr Kloser provided a bibliography of recent literature on this topic which will be placed on the SG-ASAM e-group for participants to update.

4.11 The Subgroup agreed that data exploration and research analyses benefit from a range of statistical and analytical approaches. However, analyses that provide outcomes for use in management would need to follow pre-agreed analytical procedures, and insight from other working groups (WG-EMM, WG-SAM, WG-FSA) could provide useful input into the development of appropriate statistical analyses.

Potential input into WG-EMM on the use of fishing vessel-based acoustic data in the 2015/16 multinational effort

4.12 The Subgroup reviewed the status of preparations for the 2015/16 multinational survey with respect to acoustic data collection and agreed that repeat occupation of nominated transects lines in different fishing areas should be a priority for participating fishing vessels, as repeated sampling of those transects would provide comparability with existing data.

4.13 The Subgroup noted that China, the Republic of Korea, Norway and the UK will all conduct coordinated research, including using commercial fishing vessels, in 2015/16.

4.14 The Subgroup strongly supported the proposed research by these nations and encouraged the exchange of ideas and relevant information (such as planned cruise dates for research vessels) to all interested Members through WG-EMM and through the 2016 Multi-Member Research e-group on the CCAMLR website.

Other issues and future work

Instruction manual

5.1 The Subgroup agreed that the manual (Appendix D) should be made available as a stand-alone document on the CCAMLR website in order that it can be trialled in the current fishing season. The Subgroup also encouraged feedback from users which may improve the instructions.

Future work

5.2 The Subgroup recalled Figure 1 of SC-CAMLR-XXXIII, Annex 4, which set out its future work program. The next task identified in that program was the development of a protocol for data analysis. The Subgroup agreed that this would consist of:

- analysis to generate validated acoustic data suitable for further analyses
- analysis to produce specific products from that validated acoustic data.

5.3 The Subgroup recognised that other issues may arise due to feedback from data collection and analyses in the current fishing season, noting that this process for collection and use of data from the krill fishery is still in a developmental phase.

Advice to the Scientific Committee and other working groups

6.1 The Subgroup agreed that much of the advice in the report was directed towards those Members that were actually engaged in the krill fishery and encouraged those Members to communicate the outcomes of the Subgroup meeting, especially the manual in Appendix D (see paragraphs 3.26 and 5.1) and the desirability of training scientific observers to collect acoustic data (paragraph 4.3).

6.2 Advice to the Scientific Committee on how acoustic data collected by fishing vessels might contribute to the 2015/16 multinational research effort and to FBM would be guided by discussions in WG-EMM.

Adoption of report

7.1 The report of the meeting was adopted.

Close of the meeting

8.1 In closing the meeting, the Convener thanked all participants for their contributions to the work of SG-ASAM and for the extensive intersessional activities which had advanced the development of protocols for using fishing-vessel-based acoustic data. Dr Zhao also thanked Dr Choi and his team for the excellent support and generous hospitality during the meeting. The Subgroup thanked Dr Zhao for convening the meeting.

References

Harrison, L.-M.K., M.J. Cox, G. Skaret and R. Harcourt. 2015. The R package EchoviewR for automated processing of active acoustic data using Echoview. *Front. Mar. Sci.*, 2:15, doi: 10.3389/fmars.2015.00015.

ICES. 2013. A metadata convention for processed acoustic data from active acoustic systems. SISP 3 TG-AcMeta, ICES WGFAST Topic Group, TG-AcMeta. 35 pp.

Table 1: Way points for the nominated transects for the collection of acoustic data in Subareas 48.1, 48.2 and 48.3.

Subarea	Transect	Waypoint 1		Waypoint 2	
		Longitude	Latitude	Longitude	Latitude
48.1	T2	62°30.00'W	62°00.00'S	61°30.00'W	62°30.00'S
	T3	62°00.00'W	61°45.00'S	61°00.00'W	62°15.00'S
	T13	54°30.00'W	60°00.00'S	54°30.00'W	61°45.00'S
	T14	54°00.00'W	60°00.00'S	54°00.00'W	61°03.00'S
	T16	60°30.00'W	63°00.00'S	59°30.00'W	63°30.00'S
	T17	60°00.00'W	62°45.00'S	59°00.00'W	63°15.00'S
48.2	T3	46°30.00'W	59°40.20'S	46°30.00'W	60°28.80'S*
	T4	45°45.00'W	59°40.20'S	45°45.00'W	60°28.80'S
48.3	T5	38°26.94'W	53°13.25'S	38°13.22'W	53°55.61'S
	T6	38°08.42'W	53°11.11'S	37°54.40'W	53°53.42'S
	T9	36°15.62'W	54°05.73'S	35°15.19'W	53°41.49'S
	T10	36°10.50'W	54°10.35'S	35°09.80'W	53°46.26'S

* Northern section only.

Appendix A

List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(Busan, Republic of Korea, 9 to 13 March 2015)

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Appendix B

Agenda

Subgroup on Acoustic Survey and Analysis Methods
(Busan, Republic of Korea, 9 to 13 March 2015)

1. Introduction

    1.1 Opening of the meeting
    1.2 Adoption of the agenda
    1.3 Modification/adoption of meeting agenda

2. Review proof of concept: stage 2

3. Protocols for data collection and analysis, with emphasis on Simrad echosounders (EK60, ES60/70)

    3.1 Data collection
        3.1.1 Validation of instrument performance
        3.1.2 Instructions on instrument setup
        3.1.3 Work on protocols for data collection with other echosounder/sonars where applicable

    3.2 Data screening and analysis
        3.2.1 Noise removal algorithms (standardised procedures)
        3.2.2 Data analysis (software-specific)
        3.2.3 Uncertainty evaluation methods, including data quality/data loss

4. Analysis of data collected during fishing operations

    4.1 Spatial and statistical treatment
    4.2 Potential input into WG-EMM on the use of fishing vessel-based acoustic data in the 2015/16 multinational effort as well as in FBM in general

5. Other issues and future work

6. Recommendations to the Scientific Committee

7. Adoption of report

8. Close of meeting.

Appendix C

List of Documents

Subgroup on Acoustic Survey and Analysis Methods
(Busan, Republic of Korea, 9 to 13 March 2015)

SG-ASAM-15/01	Automated data processing using Echoview M.J. Cox (Australia), G. Skaret (Norway), L.-M.K. Harrison and R. Harcourt (Australia)
SG-ASAM-15/02	A noise removal algorithm for acoustic data with strong interference based on post-processing techniques X. Wang, X. Zhao and J. Zhang (People's Republic of China)
SG-ASAM-15/03	Semi-empirical acoustic estimates of krill biomass derived from simulated commercial fishery data based on single-frequency acoustics A.M. Cossio, G.W. Watters, C.S. Reiss, J. Hinke and D. Kinzey (USA)
	***************
Presentations	Acoustic and catch data collected by the fleet – relevance for Feedback Management O.R. Godø, G. Skaret and T. Klevjer (Norway)
	Quantitative assessment of diving birds in fishing locations using vessel acoustics T. Klevjer, O.R. Godø, G. Skaret and B. Krafft (Norway)
	Overview of IMOS bioacoustic program using ships of opportunity R. Kloser, T. Ryan, G. Keith and R. Downie (Australia)
	Procedures for removing noises and strong interferences in acoustic data based on Echoview post processing software X. Wang, X. Zhao and J. Zhang (People's Republic of China)
	Software developed at IMR for synchronising pinging of various acoustic instruments O.R. Godø (Norway)

Southern Ocean Network of Acoustics
S. Fielding, A. Tate (UK), M. Cox, R. Kloser, T. Ryan (Australia), P. Brehmer, N. Behagle (France), G. Skaret, R. Korneliussen (Norway), R. O'Driscoll, A. Dunford (New Zealand), C. Reiss, A. Cossio (USA) and J. Thomas (SONA data manager) (presented by J. Watkins)

ES60/70 center calibration using Echoview
M. Kang (Republic of Korea)

Interference noise removal method
M. Kang (Republic of Korea)

Acoustic data from Korean krill fishing vessels
H. Lee (Republic of Korea)

Appendix D

Instruction manual for the collection of fishing-vessel-based acoustic data Version 1.0 16 March 2015

Preface

This manual is to be used by the person(s) who are responsible for the collection of raw acoustic data on board krill fishing vessels operating in the CAMLR Convention Area. The specific instruments covered by this manual are limited to Simrad ES60, Simrad ES70 and Simrad EK60 echosounders.

The data collected according to this manual, whether during specially designed surveys along nominated transits or during fishing operation (including searching for suitable fishing aggregation and steaming to another fishing area), are potentially very valuable and may be used to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*). This information is fundamental to CCAMLR's approach to management.

The manual consists of:

Chapter 1: A brief overview of what data should be collected, where and when it should be collected and finally how it should be collected

Chapter 2: Validation of instrument performance.

For further details please contact your national technical coordinator or Scientific Committee Representative or contact the CCAMLR Secretariat (ccamlr@ccamlr.org).

Thank you for taking the time to record these important data.

Chapter 1

A brief overview of recommendations for data collection

What data should be collected: raw acoustic data and supporting metadata describing the acoustic data and cruise should be collected. The actual acoustic data needs to have the correct metadata (the data about the data) in order to be useable. In many cases the required metadata is already available in other details submitted to CCAMLR and the need for additional data has been minimised to make the task easier.

Where data should be collected: Acoustic data, together with supporting metadata, should be collected in all of the areas for which the vessel has been licenced to fish for krill. The acoustic data collected along the nominated transects (in Table 1), as well as in the areas in which fishing actually occurs, are seen as a high priority.

When data should be collected: Acoustic data collection should begin as the vessel enters the Convention Area and be continued until the vessel leaves. Collecting data throughout the entire fishing trip is required to build up a picture of temporal variability and change in krill abundance and distribution. In particular, given the importance of the nominated transects in building up patterns of temporal variability, repeating these nominated transects as often as possible during the cruise is recommended.

How data should be collected: Raw acoustic data should be logged to a hard drive. The echosounder should be configured using the key settings detailed in Table 2.

Table 1: Waypoints for the nominated transects for the collection of acoustic data in Subareas 48.1, 48.2 and 48.3. Maps showing the location of the nominated transects are in Figure 1. Note that transects T5 and T6 could be run as a transect pair, running up one transect and down the other. Similarly, T9 and T10 could be run as a transect pair.

Subarea	Transect	Waypoint 1		Waypoint 2	
		Longitude	Latitude	Longitude	Latitude
48.1	T2	62°30.00'W	62°00.00'S	61°30.00'W	62°30.00'S
	T3	62°00.00'W	61°45.00'S	61°00.00'W	62°15.00'S
	T13	54°30.00'W	60°00.00'S	54°30.00'W	61°45.00'S
	T14	54°00.00'W	60°00.00'S	54°00.00'W	61°03.00'S
	T16	60°30.00'W	63°00.00'S	59°30.00'W	63°30.00'S
	T17	60°00.00'W	62°45.00'S	59°00.00'W	63°15.00'S
48.2	T3	46°30.00'W	59°40.20'S	46°30.00'W	60°28.80'S*
	T4	45°45.00'W	59°40.20'S	45°45.00'W	60°28.80'S
48.3	T5	38°26.94'W	53°13.25'S	38°13.22'W	53°55.61'S
	T6	38°08.42'W	53°11.11'S	37°54.40'W	53°53.42'S
	T9	36°15.62'W	54°05.73'S	35°15.19'W	53°41.49'S
	T10	36°10.50'W	54°10.35'S	35°09.80'W	53°46.26'S

* Northern section only.

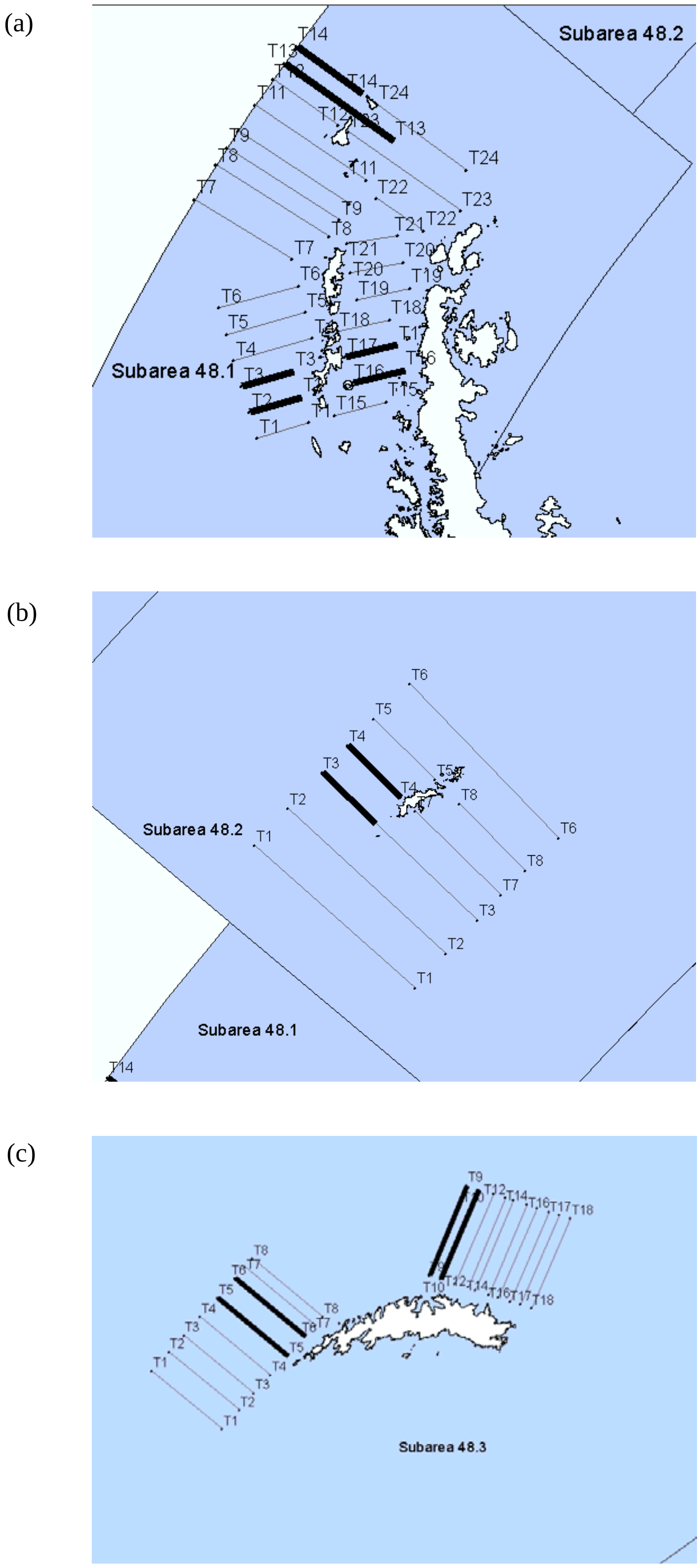


Figure 1: Location of nominated transects (thick black lines) and existing research transects for the collection of acoustic data in: (a) Subarea 48.1, (b) Subarea 48.2 and (c) Subarea 48.3.

Data Logging Instructions

1. System requirements

1.1 Echosounder

A properly functional Simrad ES60, Simrad ES70 or Simrad EK60.

1.2 Data logging device

An external hard drive with a minimum data storage capacity of 2 Tb. The actual volume of data stored depends on the number of frequencies used and the duration of the time in the Convention Area. The external hard drive is to be used both for data backup and for data delivery. It is advisable to have two hard drives in order to have a backup in case of failure of one drive.

1.3 Navigation device

A global positioning system (GPS) (with data output) connected to the echosounder.

2. Instrument parameter settings

The instrument parameters should be set according to Table 2, and should not be changed, except the display range.

Table 2: Instrument setting for data collection (modified from SC-CAMLR-XXXIII, Annex 4, Table 5).

Parameter	Unit	Setting			
Frequency	kHz:	38	70	120	200
Power*	W	2000	700	250	110
Pulse duration	microsecond	1024	1024	1024	1024
Ping interval	second	2	2	2	2
Data collection range (min.–max.)	m	0–1100	0–1100	0–1100	0–1100
Bottom detection range (min.–max.)	m	5–1100	5–1100	5–1100	5–1100
Display range (min.–max.)	m	0–1100	0–1100	0–1100	0–1100

* based on Korneliussen et al., 2008

3. Operational instruction

This set of instructions describes how to set up the echosounder for data collection. While the descriptions are primarily referring to Simrad ES60, they are similarly applicable to Simrad ES70 and Simrad EK60. Where differences do exist, please refer to the instruction manual of the specific echosounder used.

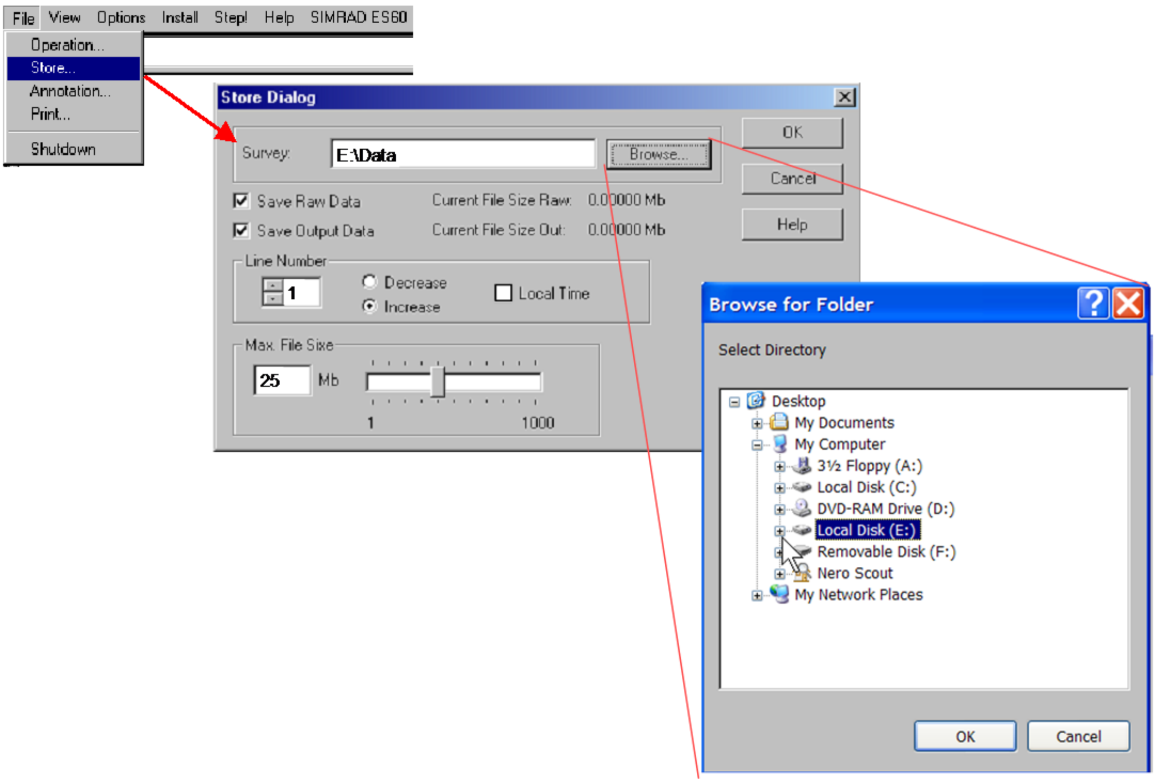
System settings

- Set data to log to a folder on the external USB hard drive
- Set ES60 PC clock to UTC and reset against GPS time source
- Log data while you are in the Convention Area.

Details on how to set up and adjust these settings are given below in steps 1 to 6.

1) Set logging directory

On the very top left-hand side of the ES60 screen, click File/Store and then the Browse button to navigate to the externally attached hard drive and select a suitable folder for the logged data. Set the file size to 25 MB and uncheck the box that says ‘Local time’.



Tip: USB drive letter will not be C and is unlikely to be D, and is probably E on most installations. Supplied drives will most likely have a folder \Data. If so, log to this folder, i.e. E:\Data*.

Tip: If you need to set up a logging directory, hold down the Windows key on the keyboard ( ) and press E. This will bring up Windows Explorer. You can then find your way to the USB hard drive and create a folder to log to.

Tip: Hold down the Alt key and press the Tab key. This will take you back to the ES60 software.

* For ES70 and EK60 recommend that the vessel uses the call sign as file suffix to the recorded data.

2) Set echosounder power and pulse duration for each frequency available

On the top of the ES60 screen, right-click on the text ‘38 kHz’, ‘120 kHz’ or ‘200 kHz’ to bring up the transceiver settings dialog. Set the power to 2 000 W (38 kHz), 700 W (70 kHz)**,** 250 W (120 kHz) or 110 W (200 kHz), ping interval to 2.0 s and the pulse length to 1 024 microseconds and click OK.

3) Set display range

Set the display range from 0 to 1 100 m by right-clicking on the right-hand side of the ES60 screen.

4) Set bottom detection range

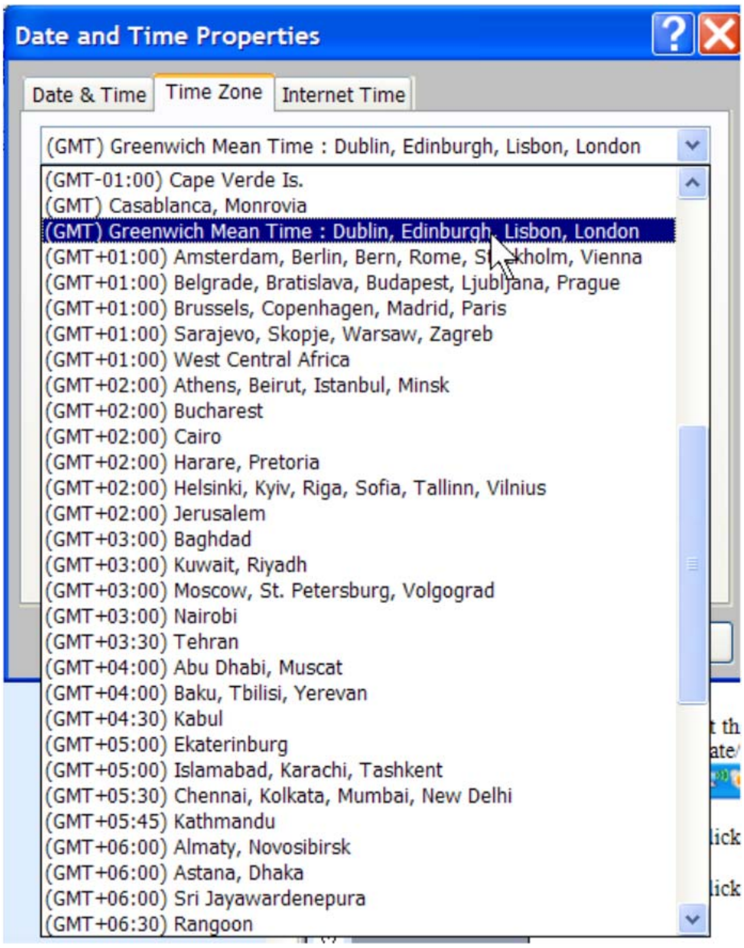
Set the bottom detection to start at 5 m and finish at 1 100 m. **Note**: if this reading is needed for navigational purposes, the depth setting should be reset.

5) Set the ES60 PC clock to UTC

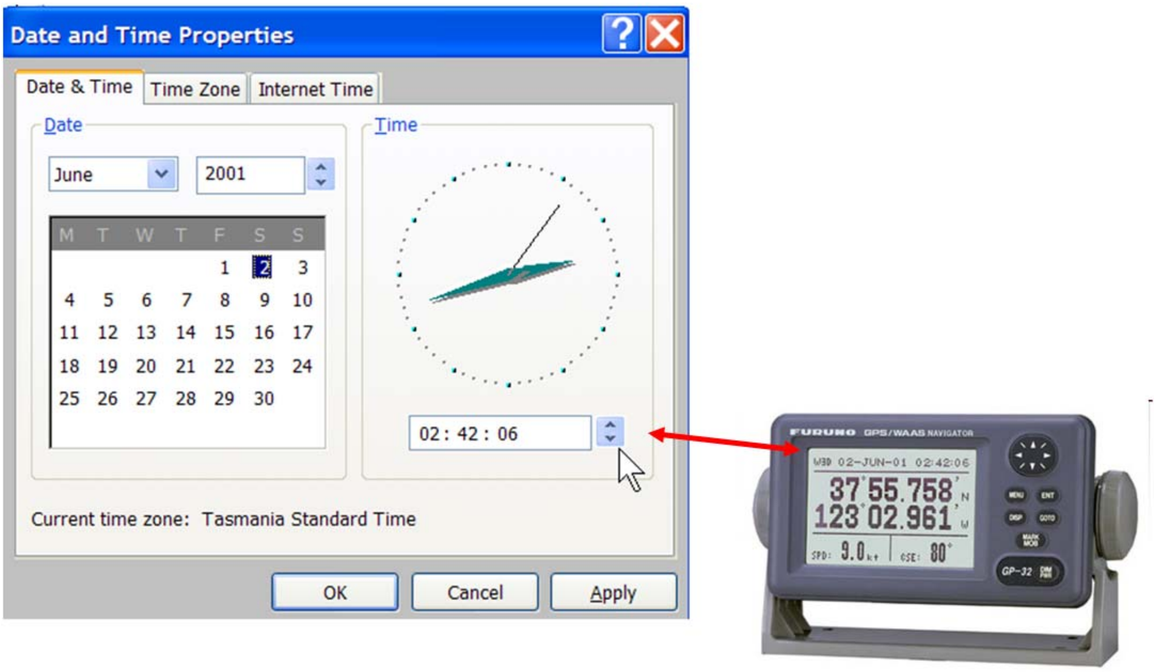
Hold the Windows key ( ) and press M to get to the ES60 PC’s desktop.

At the bottom right-hand side of the screen, double-click on the time readout to bring up the Date/Time dialog.

Click on the Time Zone tab. Select GMT from the pick list and click OK.

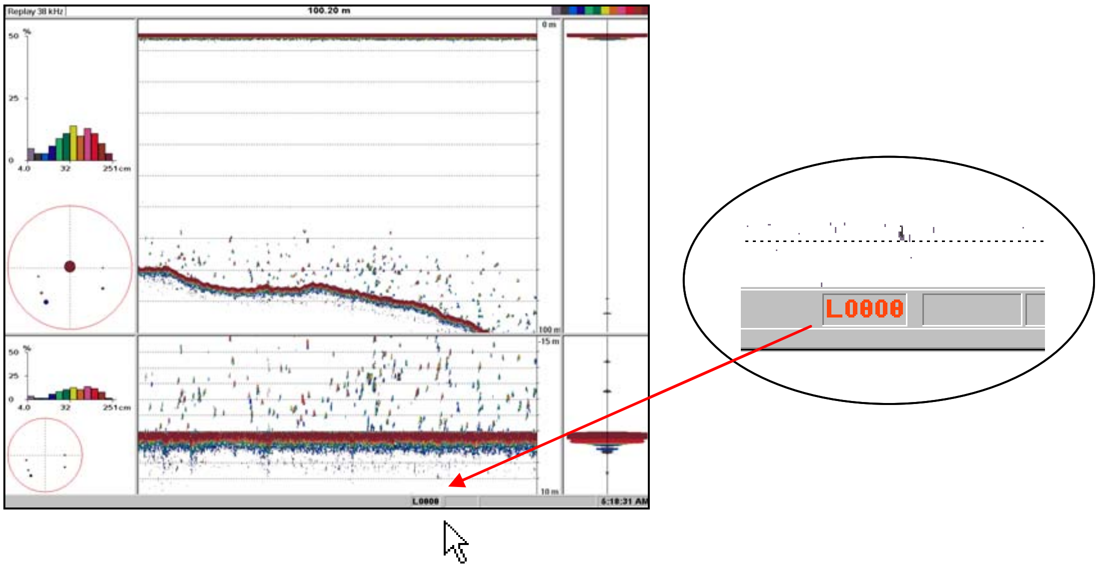


Click on the Date & Time tab. Reset the time to match the UTC time from a GPS readout.



6) Commence logging

Alt-Tab back to the ES60 software. At the bottom right-hand side, click on the text ‘L000..’. This should turn from black to red to indicate logging has commenced.



Tip: Turn off other sounders when logging in transects to avoid unwanted interference.

4. Metadata requirements

Metadata contains important information that is an essential element of the data logged and should be delivered together with the data collected.

Please fill in Table 3 at the beginning and the end of data collection. When data has been collected along nominated transects as listed in Table 1 and shown in Figure 1, please fill in the relevant metadata also. The location and waypoints for all existing acoustic transects are given in SC-CAMLR-XXXIII, Annex 4, Figure 2, and are included here (as Figure 2 and Table 4) for reference.

Table 3: Metadata required during cruise and running nominated transects.

Vessel name			
Vessel call sign			
Cruise start date (dd/mm/yy)			
Cruise end date (dd/mm/yy)			
Subarea	Transect number (ID)	Start datetime (UTC)	End datetime (UTC)

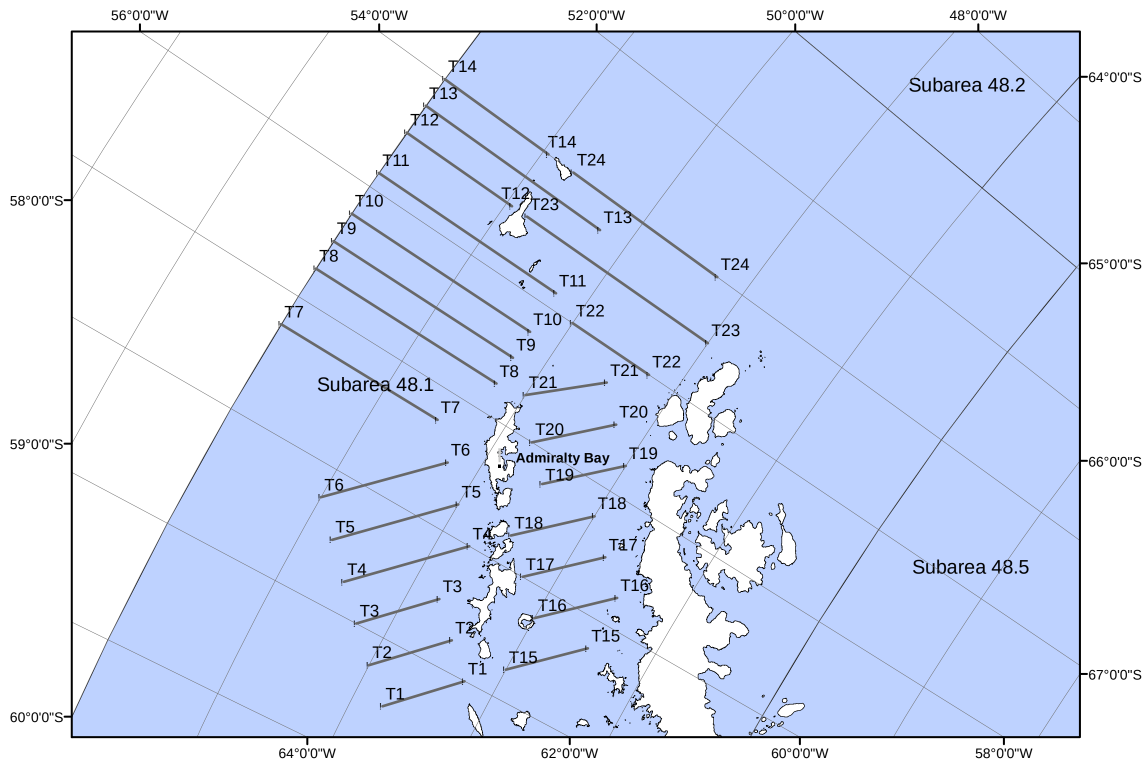


Figure 2(a): Location of acoustic transects (T1 to T24) and the calibration site (Admiralty Bay) at the South Shetland Islands (Subarea 48.1). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

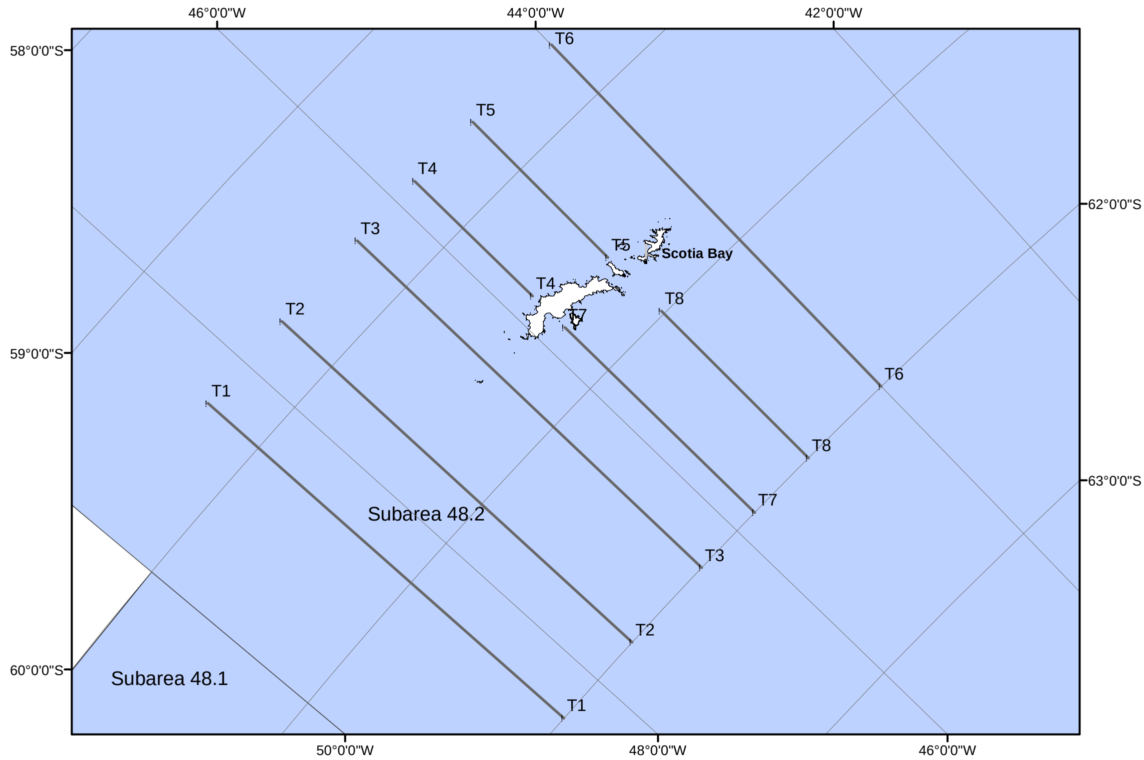


Figure 2(b): Location of acoustic transects (T1 to T8) and the calibration site (Scotia Bay) at the South Orkney Islands (Subarea 48.2). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

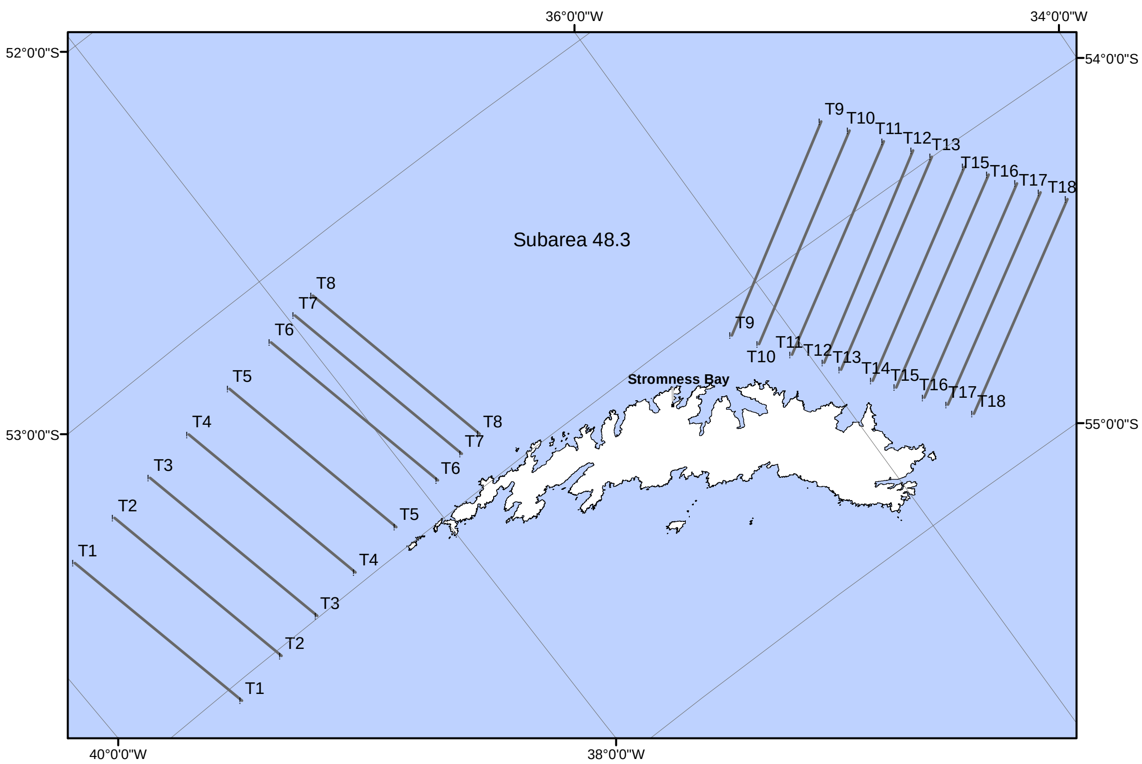


Figure 2(c): Location of acoustic transects (T1 to T18) and the calibration site (Stromness Bay) at South Georgia (Subarea 48.3). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

Table 4: Waypoints (dd mm.00) of the acoustic transects that are part of existing krill acoustic surveys in Subareas 48.1, 48.2 and 48.3 (copied from SC-CAMLR-XXXIII, Annex 4). See also Figure 2.

Subarea	Transect	Waypoint 1		Waypoint 2	
		Longitude	Latitude	Longitude	Latitude
48.1	T1	63°00.00'W	62°15.00'S	62°00.00'W	62°45.00'S
	T2	62°30.00'W	62°00.00'S	61°30.00'W	62°30.00'S
	T3	62°00.00'W	61°45.00'S	61°00.00'W	62°15.00'S
	T4	61°30.00'W	61°30.00'S	60°00.00'W	62°15.00'S
	T5	61°00.00'W	61°15.00'S	59°30.00'W	62°00.00'S
	T6	60°30.00'W	61°00.00'S	59°00.00'W	61°45.00'S
	T7	58°30.00'W	60°00.00'S	58°30.00'W	61°30.00'S
	T8	57°30.00'W	60°00.00'S	57°30.00'W	61°45.00'S
	T9	57°00.00'W	60°00.00'S	57°00.00'W	61°45.00'S
	T10	56°30.00'W	60°00.00'S	56°30.00'W	61°45.00'S
	T11	55°45.00'W	60°00.00'S	55°45.00'W	61°45.00'S
	T12	55°00.00'W	60°00.00'S	55°00.00'W	61°03.00'S
	T13	54°30.00'W	60°00.00'S	54°30.00'W	61°45.00'S
	T14	54°00.00'W	60°00.00'S	54°00.00'W	61°03.00'S
	T15	61°30.00'W	63°00.00'S	60°30.00'W	63°30.00'S
	T16	60°30.00'W	63°00.00'S	59°30.00'W	63°30.00'S
	T17	60°00.00'W	62°45.00'S	59°00.00'W	63°15.00'S
	T18	59°30.00'W	62°30.00'S	58°30.00'W	63°00.00'S
	T19	58°30.00'W	62°30.00'S	57°30.00'W	63°00.00'S
	T20	58°00.00'W	62°15.00'S	57°00.00'W	62°45.00'S
	T21	57°24.00'W	62°00.00'S	56°30.00'W	62°30.00'S
	T22	56°00.00'W	62°00.00'S	56°00.00'W	62°45.00'S
	T23	55°00.00'W	61°12.00'S	55°00.00'W	63°00.00'S
	T24	54°00.00'W	61°18.00'S	54°00.00'W	62°45.00'S
48.2	T1	48°30.00'W	59°40.20'S	48°30.00'W	62°00.00'S
	T2	47°30.00'W	59°40.20'S	47°30.00'W	62°00.00'S
	T3	46°30.00'W	59°40.20'S	46°30.00'W	62°00.00'S
	T4	45°45.00'W	59°40.20'S	45°45.00'W	60°28.80'S
	T5	45°00.00'W	59°40.20'S	45°00.00'W	60°36.60'S
	T6	44°00.00'W	59°40.20'S	44°00.00'W	62°00.00'S
	T7	45°45.00'W	60°42.00'S	45°45.00'W	62°00.00'S
	T8	45°00.00'W	60°58.80'S	45°00.00'W	62°00.00'S
48.3	T1	39°36.14'W	53°20.83'S	39°23.51'W	54°03.32'S
	T2	39°18.25'W	53°18.94'S	39°05.34'W	54°01.40'S
	T3	39°02.29'W	53°17.22'S	38°49.14'W	53°59.64'S
	T4	38°45.05'W	53°15.31'S	38°31.61'W	53°57.70'S
	T5	38°26.94'W	53°13.25'S	38°13.22'W	53°55.61'S
	T6	38°08.42'W	53°11.11'S	37°54.40'W	53°53.42'S
	T7	37°57.86'W	53°09.85'S	37°43.67'W	53°52.15'S
	T8	37°49.93'W	53°08.90'S	37°35.62'W	53°51.19'S
	T9	36°15.62'W	54°05.73'S	35°15.19'W	53°41.49'S
	T10	36°10.50'W	54°10.35'S	35°09.80'W	53°46.26'S
	T11	36°04.15'W	54°15.94'S	35°03.05'W	53°51.92'S
	T12	35°57.60'W	54°21.02'S	34°57.42'W	53°56.79'S
	T13	35°54.68'W	54°24.11'S	34°53.74'W	53°59.99'S
	T14	35°48.65'W	54°29.60'S	34°47.35'W	54°05.35'S
	T15	35°43.98'W	54°33.43'S	34°42.54'W	54°09.38'S
	T16	35°38.65'W	54°38.34'S	34°36.98'W	54°14.02'S
	T17	35°33.94'W	54°42.22'S	34°32.50'W	54°18.15'S
	T18	35°29.00'W	54°46.67'S	34°26.85'W	54°22.33'S

Chapter 2

Validation of Instrument Performance

1) External assessment of echosounder performance

Standard sphere calibration

If possible, a standard sphere calibration utilising the techniques described in Foote et al. (1987) should be carried out. Locations where regular calibrations have been carried out previously are given in Table 5.

Table 5: Positions (dd mm.00) of regularly used calibration sites in Subareas 48.1, 48.2 and 48.3. See also Figure 2.

Subarea	Calibration site	Position	
		Longitude	Latitude
48.1	Admiralty Bay	58°26.58'W	62°08.10'S
48.2	Scotia Bay	44°40.86'W	60°44.88'S
48.3	Stromness Bay	36°40.02'W	54°09.30'S

2) Seabed reflection calibration

CCAMLR is currently investigating the use of seabed reflection as another way of externally assessing echosounder performance. A protocol for such assessments will be added to this part of the document once it becomes available.

3) Internal assessments of echosounder performance

Internal validation procedures to monitor basic system performance are being developed or documented and will be added here once available.

References

Korneliussen, R.J., N. Diner, E. Ona, L. Berger and P.G. Fernandes. 2008. Proposals for the collection of multifrequency acoustic data. *ICES J. Mar. Sci.*, 65: 982–994.

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep.*, 144: 69 pp.